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TRANSACTIONS
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THE NEW YORK ACADEMY OF SCIENCES

Ser. II, Vol. 4 JANUARY, 1942 No. 3

SECTION OF GEOLOGY AND MINERALOGY[1]

DECEMBER 1, 1941

PROFESSOR ERLING DORF, Princeton University: *Application of Paleobotany to the Cretaceous-Tertiary Boundary Problem.* (This lecture was illustrated by lantern slides.)

Geologic boundaries, like political boundaries, are notoriously troublesome and subject to change. The correct placing of boundaries between rock units involves difficulties with which most geologists are familiar. These rock units are generally assigned to units of the geologic time-table by means of their fossilized organic remains, wherever possible. Important observable changes in the faunas and floras of successive rock units have led to the recognition of the nebulous abstractions known as "time boundaries" between geologic epochs, periods, and eras. Such boundaries, though obviously as non-existent as any observable boundary between Monday and Tuesday, are translated into concrete reality by reference, if possible, to the horizon in the rock succession at which the organic changes are seen to take place.

[1]No meetings were held in December by the Sections of Psychology and Anthropology.

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Associate Editor: Eunice Thomas Miner, Executive Secretary.

Entered as second-class matter December 2, 1938, at the post office at Lancaster, Pa., under the act of August 24, 1912.

To be specific, the boundary between Mesozoic time and Cenozoic time cannot be observed, except in terms of a boundary between rock units containing recognized Mesozoic fossils and recognized Cenozoic fossils.

By universal agreement, fossils of the Cretaceous system have come to be regarded as belonging to Mesozoic time and those of the Tertiary system, to Cenozoic time. The well-recognized and widespread Cretaceous fossils include ammonites and certain groups of pelecypods, dinosaurs and primitive mammals, and primitive dicots and conifers. In the Tertiary system, ammonites and dinosaurs are lacking, as are most of the genera of primitive dicots and conifers. Instead, are found gastropods and different groups of pelecypods, modernized mammals, and modernized dicots and conifers. The placing of the Cretaceous-Tertiary boundary is, therefore, a problem involving agreement among invertebrate paleontologists, vertebrate paleontologists, and paleobotanists as to the more or less exact horizon where the observable change from Cretaceous to Tertiary organisms actually takes place.

In the sedimentary succession of the Atlantic, Gulf, and Pacific coast regions, the Cretaceous-Tertiary boundary has been established between successive marine deposits and, therefore, has been primarily a problem for invertebrate paleontologists. In the western interior, however, the succession includes both marine beds with invertebrate remains, and terrestrial beds with plants and vertebrates. Here, the problem is to place the boundary at a stratigraphic level acceptable alike to the students of invertebrates, vertebrates, and plants. That there has continued to be a problem in connection with the boundary in this region for over 30 years is evidence of an unfortunate lack of agreement among paleontologists which, it is hoped, will not continue much longer.

In approaching a clarification of the paleobotanical aspects of the Cretaceous-Tertiary boundary, one might well first ask, "What's the argument all about?" In 1921, Matthew defined the issue as follows: "A Cretaceous vertebrate fauna was found associated with a Tertiary flora. Vertebrate paleontologists and paleobotanists took opposite sides; the stratigraphic geologists

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were divided . . . this discrepancy has been maintained and confirmed by all subsequent work."

This disagreement arose chiefly from data and collections obtained from beds referred to the Lance formation in eastern Wyoming, Montana, and the Dakotas. In the same year, 1921, Stanton reported that the marine invertebrates of the upper (Cannonball) member of the Lance were of late Cretaceous age, thus aligning the invertebrate and vertebrate paleontologists together on one side of the fence and the paleobotanists alone on the other. The stratigraphic relations of the various units involved in the argument were, at about this time, generally understood to be as follows:

	Eastern Wyoming	*Montana and the Dakotas*
Tertiary	Fort Union	Fort Union { Tongue River member / Lebo member
Tertiary? / Upper Cretaceous?	Lance	Lance { Tullock, Ludlow, or Cannonball member / Hell Creek member
Upper Cretaceous (Montana group)	Fox Hills sandstone	Fox Hills sandstone

Of these units, only the Fox Hills sandstone and the Cannonball member of the Lance had yielded marine invertebrates. The remaining units contained terrestrial plants and vertebrates.

My own connection with the paleobotanical aspects of the Cretaceous-Tertiary boundary problem began in 1934 with the study of the Medicine Bow flora of southern Wyoming and continued in 1936 and 1938 with the flora of the Lance formation at its type locality in eastern Wyoming. My conclusions may be briefly summarized as follows:

(1) A complete analysis of the flora of the Lance formation at its type locality indicates its late Cretaceous age. The flora is definitely not an early Tertiary "Fort Union" flora, as Knowlton had concluded. It is now clear, as Stanton had intimated as early as 1909, that Knowlton's so-called "Lance" flora was in reality a mixed flora, obtained only in part from the true dinosaur-bearing Lance. A large part of the plant collection had actually been obtained from beds which are stratigraphically above the true Lance

and which are neither genetically nor paleontologically related to the true Lance.

(2) Analyses of the Medicine Bow and Lance floras of the type localities show that these late Cretaceous floras correlate with the flora of only the lower (Hell Creek) member of the Lance and do not correlate with the flora of the so-called upper (Tullock-Ludlow) member of the Lance in Montana and the Dakotas. Analyses of the type Tullock and type Ludlow floras indicate their early Tertiary (Paleocene) age. Further investigation of the localities from which Knowlton had obtained his so-called "Lance" flora reveals that nine localities are in the Tullock or Ludlow, and, in addition, ten other localities are in lithologic equivalents of the Tullock or Ludlow, above the true dinosaur-bearing Lance. By including the plants (38 species) from these localities in his "Lance" flora, Knowlton was obviously impressed by the Tertiary "Fort Union" aspect of the flora. Knowlton, apparently, was led to believe that the Tullock and Ludlow beds were justifiably regarded as part of the true Lance formation on the basis of reliable evidence—though certainly not plant evidence. That the evidence was not reliable has been repeatedly pointed out by vertebrate paleontologists, notably Simpson, as early as 1929. Apparently, a single dinosaur horn core, found loose on the surface, was the only paleontological basis for the original inclusion of the Tullock in the Lance. Subsequent search in both the Tullock and Ludlow beds has failed to turn up additional dinosaur remains. Unfortunately, however, no other reliable vertebrate remains have been found in the Tullock or the Ludlow. Their age assignment to the early Tertiary by the vertebrate paleontologists has, therefore, been based upon negative evidence. The positive evidence of the plant remains substantiates such an assignment.

(3) The paleobotanical evidence now places the Mesozoic-Cenozoic boundary between the true dinosaur-bearing Lance formation and the overlying basal unit of the Fort Union group. In Montana, this corresponds to the boundary between the Hell Creek formation (= true dinosaur-bearing Lance) and either the Tullock formation or the Ludlow formation (from west to east),

both of which were originally, and erroneously, regarded as upper Lance. In eastern and central Wyoming, the boundary is placed between the type Lance or its recognized equivalents and the overlying Fort Union "formation." Throughout this region, except near the Montana border, the Tullock-Ludlow equivalents were correctly included, both originally and subsequently, in the Fort Union sediments above the true dinosaur-bearing Lance.

(4) In the Dakotas, the paleobotanical evidence was, until 1940, not in harmony with the invertebrate evidence regarding the position of the Cannonball marine beds in the geologic time-scale. Since the Cannonball beds interfingered westward with the Ludlow formation, which had yielded a Paleocene flora, the Cannonball was naturally regarded as above the Mesozoic-Cenozoic boundary. This stratigraphic-paleobotanic conclusion disagreed with the conclusion of Stanton that the invertebrates of the Cannonball were Cretaceous. The recent description of a Paleocene foraminiferal fauna in the Cannonball by Fox and Ross seems finally to bring into harmony the varying views regarding the age of these and equivalent beds, as follows:

	Eastern Wyoming	*Montana and the Dakotas*	
Tertiary (Paleocene)	Fort Union "formation"	Fort Union group	Tongue River formation Lebo formation Tullock, Ludlow or Cannonball formation
Upper Cretaceous	type Lance formation	Hell Creek formation	

(5) In other parts of the western interior, a comparison of various controversial floras with those of the type Lance, Hell Creek, and Fort Union floras has given rather positive results.

In the Denver basin of Colorado, the floral evidence points definitely to the assignment of the Laramie, the Arapahoe-Lower Denver, and the lower Dawson formations to the late Cretaceous, and of the upper Denver and upper Dawson to the Paleocene. This conclusion has recently been corroborated by the report by Brown and Gazin of the discovery of Paleocene mammals in the upper part of the Denver formation, above a recognizable lithologic break.

In south-central Colorado, the Vermejo and lower Raton floras are now interpreted as of late Cretaceous age and the upper Raton, as Paleocene. The exact position of the Mesozoic-Cenozoic boundary in this section has as yet not been determined. In western Colorado, floras from the beds referred to the "Laramie" formation are regarded as late Cretaceous and those from the so-called "Post-Laramie," as Paleocene. The Mesozoic-Cenozoic boundary is in this region well-marked by a distinct unconformity.

In southern Wyoming, the floral evidence places the Mesozoic-Cenozoic boundary between the Medicine Bow formation and the Ferris formation at a well-defined lithologic break. In southwestern Wyoming, the flora of the Black Buttes "Laramie" is late Cretaceous, whereas that of the overlying "Post-Laramie" is Paleocene. The boundary between these two units is generally marked by an angular unconformity.

These conclusions may be diagrammatically summarized as follows:

	Central and Eastern Colorado		*South-central Colorado*	*Southwestern Wyoming and adjacent Colorado*	
Paleocene (Fort Union)	Upper Denver	Upper Dawson	Upper Raton	Hanna-Ferris	"Post-Laramie"
Late Cretaceous (Lance)	Lower Denver-Arapahoe	Lower Dawson	Lower Raton-Upper Vermejo	Medicine Bow	"Laramie"

The problems in connection with the Mesozoic-Cenozoic boundary are by no means settled. Yet, there seems now to be a nearer approach to agreement between the interpretation of the vertebrate, invertebrate, and plant evidence, as to its position than at any previous time. We still know very little, however, of the reasons why such marked changes in the organisms of both land and sea took place at so nearly the same "moment" in geologic time. There is still much to be done.

SECTION OF BIOLOGY

DECEMBER 8, 1941

DOCTOR ALBERT CLAUDE. The Rockefeller Institute for Medical Research, New York, N. Y.: *Mechanical Separation of the Morphological Constituents of the Cell.* (This lecture was illustrated by lantern slides, microscopic preparations and specimens).

Extensive use of microscopical techniques and of selective staining in the study of cell structure has made it possible to distinguish two main components in the constitution of protoplasm: (a) a fundamental ground substance, capable of reversible gelation; (b) a number of inclusions which may vary by their size, their shape, their chemical composition and their complexity. The most conspicuous of these inclusions is the nucleus, itself characterized by two distinct formations, the chromatin and the nucleolus. Nuclei and mitochondria are present in every active cell and are, apparently, indispensable constituents of protoplasm. Other inclusions appear only in the cytoplasm of certain cell types and represent a specialized function of the cell. Belonging to the latter category are the secretory granules, such as the zymogen granules of the salivary gland and pancreas, and pigment granules, such as the melanin granules present in abundance in amphibian liver. Little is known regarding the chemical composition of the different cell structures, although their existence has been demonstrated repeatedly by the use of a variety of cytological techniques. The reason for the lack of information is that the analysis of the cell constituents had to depend on micro-tests which are not chemically specific. One exception is the nucleal reaction of Feulgen which, under proper conditions, will detect the presence of thymonucleic acid.

It is obvious that no great advance can be made in the study of cell structure unless we succeed in separating the various cell constituents and obtain them in quantities sufficient to permit the application of the usual analytical methods. The fact that units of different or similar chemical constitution may exist independ-

ently in the relatively uniform medium of the cell indicates that chemical or physical affinity between these elements is not very great. These conditions would appear to be favorable for the separation of cell constituents by mechanical means. In recent years, a number of particulate elements have been isolated from the cytoplasm of various cells and the results indicate that the method may be extended to many other tissues and to other constituents of the cell (1). The method of separation consists in breaking up the cells, suspending the fragments in a proper solvent, usually neutral water, and fractionating the suspension in a high speed centrifuge (1). By using a period of centrifugation of one hour and a centrifugal force of 18000× gravity, small particles ranging in size between 60 and 300 mμ diameter were obtained. Evidence has been presented to show that particles isolated in this manner may be mitochondria or fragments of mitochondria (1). The chemical consitution of these tissue particles appears to be quite uniform, irrespective of the cells from which they are prepared. Essentially, these tissue particles are complexes made up of phospholipids and nucleoproteins of the ribose type, the lipoid portion accounting for 40 to 50 per cent of the whole particle. The free particles agglutinate rapidly in slightly acid solutions. They are destroyed by acid, alkali, and by heat, and disruption of the particles by these agents is accompanied by release of free nucleic acid in the solution. Particles of this type have been found in practically every tissue, and no tissue has been examined so far which did not contain them. They appear to have a universal distribution and, like mitochondria, to be constant constituents of protoplasm.

Two other types of granules were isolated from the guinea pig liver, in addition to the usual small particle. One of these fractions is made of elements 40 to 60 mμ in diameter, thus definitely smaller than the usual "mitochondria" particles. When freshly prepared, this fraction is pink to bright red in color. In the centrifuge, it forms jelly-like pellets which are completely transparent. The origin and function of these sub-microscopic elements have not been ascertained. The third liver fraction is

composed of granules large enough to be seen under the ordinary microscope, their size ranging between 0.5 μ and 3 μ in diameter. These large granules are referred to as "secretory granules." Chemically, the large granules are composed of phospholipids, which account for about 20 to 24 per cent of their mass, the remaining part being represented mainly by a nucleoprotein of the ribose type (1). Thus, the secretory granules, in their general make-up, resemble the small particles. The results of elementary analysis, however, indicate that the two fractions constitute two distinct groups of cytoplasmic elements. The small particles have consistently been found to contain 9 per cent nitrogen and about 1.5 per cent phosphorus. Characteristic values for the secretory granules of the guinea pig liver are about 12 per cent nitrogen and 0.9 per cent phosphorus.

From their size, it is apparent that many of the particles isolated in the centrifuge are beyond the power of resolution of the ordinary microscope and their particulate nature must have escaped detection by the usual cytological techniques. The possibility that these sub-microscopic elements may progressively develop into visible granules is a point of particular interest, especially in view of the mode of origin of mitochondria. That a relation may prove to exist between the different classes of granules, namely, the small particles and the large "secretory granules," is suggested by the fact that, so far, all have been found to be complexes made essentially of phospholipids and nucleoprotein, these two main components occurring in various proportions in the different types of granules. In the present study, the terms, mitochondria and secretory granules, to designate the free elements, are used only tentatively, until a complete inventory of the cytoplasmic contents can be made by means of the centrifugation technique.

By the simple technique of differential centrifugation at high speed, pigment in the form of granules can also be isolated from the cell. The liver of amphibia is rich in a brown pigment which resembles melanin (2). In the present work, the liver of *Amphiuma tridactylum* was used as the source of pigment. The

melanin granules were separated from the other components of the cell and washed in neutral water, by submitting them to alternate centrifugation of three minutes at 18000 × gravity, and 1 minute at 1500 × gravity. In the dark field microscope, the purified pigments appears to be composed of slightly elongated granules, very uniform in size, and about 1 μ × 0.5 μ in diameter. From their rate of sedimentation, these melanin granules appear to have an unusually high density. The results of chemical analysis are not yet available. As an extension to this work, it has been found that the guinea pig liver also contains a small proportion of "melanin granules" which, in the purified form, are strikingly similar to the pigment granules isolated from amphibian liver.

Since the time of Miescher, chemists have endeavored to determine the chemical composition of cell nuclei. In order to secure material as free as possible of cytoplasmic contaminents, studies on cell nuclei were usually restricted to the analysis of fish sperm, pus cells, and nucleated blood corpuscles (3). In recent years, the rapid development of the work on heredity and structure of chromosomes has created a renewed interest in the chemical composition of chromatin. Work of this laboratory, in collaboration with Dr. James S. Potter, has shown that chromatin strands could be isolated from the resting nucleus, and obtained in a purified form in sufficient quantity for chemical analysis. Morphologically, the purified material is represented by double strands of chromatin, stained selectively by the Feulgen technique. Upon treatment of the dry chromatin with chloroform, the strands take a beaded appearance, due to the fact that staining with the Feulgen technique is now localized on individual grains distributed along the original chromatin thread. The chromatin strands obtained from the cells of mouse leukemia contain 15.7 per cent nitrogen and 3.65 per cent phosphorus. The latter figure suggests that about 40 per cent of the chromatin thread is nucleic acid. Whether this value corresponds to thymonucleic acid exclusively or includes also some nucleic acid of the ribose type has not been determined.

Summary. In the present work, morphological constituents of protoplasm, both of cytoplasmic and nuclear origin, were isolated by mechanical means. The different components of cytoplasm, which have been examined so far, appear to be complex formations characterized by the presence of nucleoproteins of the ribose type occuring in association with various proportions of phospholipids. The type of organization of the cytoplasmic granules contrasts with the composition of chromatin, which is characterized by the absence, or a very low content, of lipids, and a relatively high content of thymonucleic acid. It may be significant, however, that both cytoplasmic and nuclear structures are built on a framework of nucleoproteins.

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(1) Claude, Albert
1940. Science, 91: 77.
1941. Cold Spring Harbor Symposia on Quantitative Biology 9: 263.

(2) Zylberszac, S.
1938. Arch. Anat. Microsc. 34: 277.

(3) Gulick, A.
1941. Botanical Review 7: 433.

REPORT OF THE ANNUAL MEETING

DECEMBER 10, 1941

The 124th Annual Meeting of the Academy for the election of Officers, Fellows and Honorary Members, the presentation of reports and the transaction of other business was held at the Hotel Astor on the evening of Wednesday, December 10.

The Corresponding Secretary reported that there are now 46 Honorary Members and 4 Corresponding Members upon the rolls of the Academy. Three deaths were reported during the past year.

The Recording Secretary reported that the most outstanding fact regarding the Academy this year, is the continuance of its substantial progress, in spite of existing world conditions. It has published more noteworthy papers, held more important conferences, and increased its membership, of well known scientific workers, to a greater degree than in any previous year. In addition, it has added another new and important Section, that of Oceanography and Meteorology.

During 1941, the Academy held 7 Business and 26 Regular Sectional Meetings at which 29 stated papers, all of very high caliber, were presented. Six informal receptions were held under the auspices of the various Sections of the Academy, in honor of prominent speakers.

The Section of Physics and Chemistry held four conferences on special subjects of research under the following titles: "X-Ray Diffraction," "Viscosity," "Immunochemistry," and "The Ultracentrifuge." Another conference was held in the field of astronomy, on "The Fundamental Properties of the Galactic System," under the auspices of the Council.

The meetings of the new Section of Oceanography and Meteorology, now the sixth section in the Academy, will take the form of conferences to be held at suitable times during the year.

The Recording Secretary expressed his appreciation and thanks to the members of the Academy for their generous and

continued enthusiastic support of our activities, and especially so, during the past year.

One Honorary Member, 5 Life Members, 10 Sustaining Members, 310 Active Members, 215 Associate Members, and 11 Student Members were added to the rolls. Thus, a total of 552 new members were added during the year.

The present membership of the Academy is 2,012, which includes 1 Patron, 105 Life Members, 150 Sustaining Members, 964 Annual Active Members, 691 Associate Members, 51 Student Members, 46 Honorary Members and 4 Corresponding Members. Of these, 238 are Fellows.

The Editor reported that during the fiscal year of 1941, the Academy has published more than in any other single year in its history. The total number of pages is 1613, which is 473 pages more than in 1940. Of this amount, 897 pages were published in the Annals, 228 in the Transactions, and 488 in the Scientific Survey of Porto Rico and the Virgin Islands. In addition to this, there is one paper now in galley proof which will appear as Volumn 42, Article 4 of the Annals. This paper will be 130 pages in length, and will complete the volume, bringing the total number of pages published, to 1743.

A list of these publications is as follows:

ANNALS

Volume XL, Article 5—"Dielectrics," by William O. Baker, J. D. Ferry, Raymond M. Fuoss, Paul M. Gross, Marcus E. Hobbs, John G. Kirkwood, S. O. Morgan, Hans Mueller, J. L. Oncley, Herbert A. Pohl, J. Shack, Charles P. Smyth, J. H. Van Vleck. Pages 289–482. Published, December 31, 1940.

This completes Volume XL.

Volume XLI, Article 1—"The Internal Constitution of the Stars," by Zdenek Kopal, Robert E. Marshak, Henry Norris Russell, Harlow Shapley, Jaakko Tuominen. Pages 1–76. Published, March 18, 1941.

Volume XLI, Article 2—"Crystalline Protein Molecules," by Edwin J. Cohn, I. Fankuchen, J. L. Oncley, H. B. Vickery, and B. E. Warren. Pages 77–168. Published, May 23, 1941.

Volume XLI, Article 3—"The Primary Process in Photochemistry," by W. Albert Noyes, Jr., E. W. R. Steacie, Hugh S. Taylor, Edward Teller, and W. West. Pages 169–240. Published, June 30, 1941.

Volume XLI, Article 4—"The Amphoteric Properties of Proteins," by R. Keith Cannan, A. Kilbrick, John G. Kirkwood, L. G. Longsworth, A. H. Palmer, and Jacinto Steinhardt. Pages 241–328. Published, July 31, 1941.

Volume XLI, Article 5—"Sensory Cues used by Rattlesnakes in their Recognition of Ophidian Enemies," by Charles M. Bogert. Pages 329–344. Published, August 4, 1941.

This completes Volume XLI.

Volume XLII, Article 1—"A Survey of the Literature on Artistic Behavior in the Abnormal: II. Approaches and Interrelationships," by Anne Anastasi and John P. Foley, Jr. Pages 1–112. Published, August 11, 1941.

Volume XLII, Article 2—"The Fundamental Properties of the Galactic System," by B. J. Bok, Dirk Brouwer, W. J. Luyten, D. A. MacRae, H. R. Morgan, Jan Schilt, Frederick H. Seares, Peter van de Kemp, and Emma T. R. Williams. Pages 113–272. Published, October 15, 1941.

Volume XLII, Article 3—"Studies on the Origin and Early Evolution of Paired Fins and Limbs," by William K. Gregory and Henry C. Raven. Pages 273–360. Published, November 15, 1941.

Volume XLII, Article 4—"Intelligence in Mental Disorders," by Anne Roe and David Shakow. Pages 361–490. *In galley proof.*

THE SCIENTIFIC SURVEY OF PORTO RICO AND THE VIRGIN ISLANDS

Volume III, Part 4—"The Tertiary Foraminifera of Porto Rico," by J. J. Galloway and Caroline E. Heminway. Pages 273–492. Published April 21, 1941.

Volume III, Part 4—Title page and contents.

Volume XVI, Part 3—"Bryozoa of Porto Rico with a Resumé of the West Indian Bryozoan Fauna," by Raymond C. Osburn. Pages 319–488. Published, December 31, 1940.

Volume XVIII, Part 2—"A Large Archaeological Site at Capa, Utuado, with Notes on other Porto Rico Sites Visited in 1914–1915," by J. Alden Mason. Appendix. An Analysis of the Artifacts of the 1914–1915 Porto Rican Survey," by Irving Rouse. Pages 207–304. Published, March 10, 1941.

TRANSACTIONS

Transactions, Series II, Volume 3, together with the title page and table of contents, constituting a 228 page volume have been printed and distributed.

The Librarian reported that 19,657 separate publications were distributed to the members of the Academy, authors, exchanges and the sales list, classified as follows: *Annals*, 13,896; *Scientific Survey of Porto Rico and the Virgin Islands*, 1,365; *Special Publications*, Volume I, "Climate and Evolution," 48; and *Transactions*, Series II, Volume 3, complete volumes, 2,128 and 4,348 single copies.

The Library of the Academy has received 1,406 separate publications, from its exchange institutions.

The Treasurer reported that the activities of the Academy included within the fiscal year ending November 30, 1941, proved gratifying both from the point of view of increased income and administrative achievement.

A total income from all sources of $25,336.13 was received for the year as compared with $21,993.47 received during the previous fiscal year, thus indicating an increase of 15.2%. These larger receipts were substantially due to a record growth in membership and an unusual increase in the sales of publications. Three thousand dollars was received from Puerto Rico, which, with the balance of $676.61 still remaining from the previous year, placed to our credit $3,676.61, as available for financing the current publications of The Scientific Survey of Porto Rico and the Virgin Islands.

A noteworthy increase in publications was made possible in the appropriation of sums totalling $11,583.69, as compared with $7,648.95 for the previous year.

The expenses of the important meetings and conferences, held during the year, totaled $1,068.99.

The record of membership expansion was another important

factor which added to the increased income. The amount received from this source was used for administrative purposes; the printing and distribution of our publications, mainly Transactions; and $1,019.00 of it was added to the investment funds of the Academy.

During the year, the investments of the Academy were carefully analyzed, some of the holdings sold, and other securities purchased by the Treasurer, acting in conjunction with the Finance Committee and the Council. These changes were of advantage to the Academy, increasing the book value of its property from $90,136.84 as of November 30, 1940, to $92,490.49 as of November 30, 1941. Of this amount, $76,783.58 is in stocks and bonds. The income derived from all Academy investments amounted to $4,231.86, thus giving a yield of 4.2%, as compared with 4.1% earned during the year which ended November 30th, 1940.

As usual, the books of the Treasurer were duly checked and balanced at the end of the fiscal year, November 30, 1941, and audited by the Finance Committee, as provided by the Constitution and By-Laws. The property of the Academy was verified and the Treasurer's Report examined and attested by the Finance Committee as of December 9, 1941.

The A. Cressy Morrison Prizes of $200.00 each for the two most acceptable in any field of natural science, within the scope of the Academy and its Affiliated Societies were awarded to the following papers, entitled:

"Thermodynamic Properties of Solutions of Long-Chain Compounds," by Maurice L. Huggins, Eastman Kodak Company, Rochester, New York, and, "The Vernay Collection of Cretaceous (Albian) Ammonites from Angola," by Otto H. Haas, The American Museum of Natural History, New York City.

Honorable Mention was given to the paper entitled, "Studies on Complement," by Enrique E. Ecker and L. Pillemer, Institute of Pathology, Western Reserve University, Cleveland, Ohio.

The George Frederick Kunz Prize of $200.00 for the best

paper offered in the fields of Geology and Mineralogy was awarded to the paper entitled:[1]

"Development of the Northern Allegheny Synclinorium and Adjoining Regions," by G. Marshall Kay, Columbia University, New York City.

The Committee takes great pleasure in congratulating the authors of these papers upon the excellent treatment of their subjects and the fundamental importance of their results.

It seems appropriate, at this time, to call to the attention of the Academy members that, although Mr. Morrison did not offer a prize in the field of astronomy this year, he did contribute the sum of $500.00 toward defraying the publications costs of the paper entitled, "The Fundamental Properties of the Galactic System," which was published in the Annals and consists of the papers presented by the astronomers at their conference held under the auspices of the Academy on May 2 and 3, 1941.

The Committee is pleased to announce that Mr. Morrison has generously renewed the offer of two prizes, each of $200.00, for this coming year, the awards to be made at the next Annual Meeting, which will be held in December, 1942. These prizes, again, are offered for the two most acceptable papers in natural science within the scope of the Sections of the Academy and its Affiliated Societies. The precise terms of the competition will be published in a later issue of the *Transactions* and will be distributed to all members of the Academy and Affiliated Societies.

The following members were elected to Fellowship:

Harold A. Abramson, M.D.
George W. Bachman, Ph.D.
Donald Belcher, Ph.D.
Max Bergmann, Ph.D.
Kenneth Clark Blanchard, Ph.D.
Charles M. Bogert, M.A.
Walter H. Bucher, Ph.D.
Charles Lalor Burdick, Ph.D.
John T. Edsall, M.D.
William Etkin, Ph.D.
Frank Fremont-Smith, M.D.
William J. Hamilton, Jr., Ph.D.
Margaret Mead, Ph.D.
Karl F. Meyer, Ph.D., M.D.
Walter R. Miles, Ph.D.
Melvin Mooney, Ph.D.
William Moore, Ph.D.
Henry W. Nisson, Ph.D.
John B. Reeside, Ph.D.
Curt P. Richter, Ph.D.

[1]This prize was offered in accordance with the terms of a bequest of the late George Frederick Kunz and is part of the accumulated annual income from the sum of $1,000.

Edward C. Rosenow, M.D., LL.D., D.Sc.
Alexandre Rothen, Chem.E., D.Sc.
Walter I. Slichter, E.E.
Athelstan F. Spilhaus, S.M.
Horace van Norman Hilberry, A.B.
Frank L. Horsfall, Jr., A.M.
Cecil V. King, Ph.D.
Lewis G. Longsworth, Ph.D.
Daniel Ludwig, Ph.D.
John J. Lynch, A.M.
Douglas A. MacFayden, M.D.
Wilbur G. Valentine, Ph.D.
John Christian Warner, Ph.D.
John A. Wheeler, Ph.D.
Charles H. Willey, Ph.D.

Honorary Life Membership was conferred upon the following eminent scientists:[1]

Peter J. W. Debye, Ph.D., Sc.D., Physicist, Head, Department of Chemistry, Cornell University, Ithaca, N. Y.

Karl Landsteiner, M.D., Sc.D., Pathologist, Immunologist, Member, Rockefeller Institute for Medical Research, New York, N. Y.

The following officers were elected:

For President
HORACE W. STUNKARD

For Vice-Presidents
WALTER H. BUCHER
DOROTHEA MCCARTHY
THEODORE SHEDLOVSKY
CHARLES M. BREDER, JR.
MARGARET MEAD
ATHELSTAN F. SPILHAUS

For Recording Secretary
DUNCAN A. MACINNES

For Corresponding Secretary
W. REID BLAIR

For Treasurer
MARVIN D. THORN

For Librarian
BARNUM BROWN

For Editor
WILBUR G. VALENTINE

For Councilors (1942–1945)
ERICH M. SCHLAIKJER
C. STUART GAGER
VICTOR K. LA MER

For Councilor (1942–1944)
CHARLES C. MOOK

For Councilor (1942–1943)
H. HERBERT JOHNSON

For Finance Committee
HERBERT F. SCHWARZ, CHAIRMAN
WAYNE M. FAUNCE
HARDEN F. TAYLOR

[1]The class of Honorary Life Membership of The New York Academy of Sciences is limited to fifty.

After the Business Meeting, the following program was presented:

Address by the Retiring President

"The Accident of Size"

by

PRESIDENT ROY WALDO MINER

"Interaction Between the Hydrosphere and the Atmosphere"[1]

by

C. O'D. ISELIN

These papers, and also abstracts of those awarded the Academy Prizes, are included in this issue of the TRANSACTIONS.

[1]Due to unavoidable circumstances, Mr. Iselin was unable to read his paper in person. At his request, the paper was read by Mr. Athelstan F. Spilhaus.

THE NEW YORK ACADEMY OF SCIENCES

Address of the Retiring President*
given at Annual Dinner and Meeting

December 10, 1941

DOCTOR ROY WALDO MINER, The American Museum of Natural History: *The Accident of Size.* (This address was illustrated by lantern slides and motion pictures).

It is difficult for the average person, in everyday life, to realize how completely he is limited by the range of his imperfect senses in judging of the importance of his environment, and how prone he is to overlook vital entities of its composition merely because of their small size in comparison with himself.

A cluster of common mussels, casual oyster or dead scallop shells, picked up in a tidal stream, fragments of rock-weed or bits of eel-grass, are seen to be covered with hard, spreading, or tubular encrustations of limy consistency or encased in jelly-like layers of variegated pattern. Here and there, tassel-like tufts or branching growths adhere to the stems of the sea-weed. All, however, are so inconspicuous and appear so casual in character, that the stroller by the sea-side passes them over, or, crushing them between his fingers, tosses them aside as of no importance.

Yet, if a few such clusters be placed in a dish of sea-water beneath a microscope, new worlds of life leap into view. The coiled limy tube-like entanglements on the outer surface of the dead scallop-shell resolve themselves into dwellings of gorgeously colored tube-building worms (*Hydroides dianthus*), so delicately flower-like in appearance that they are otherwise known as "sea-carnations." Their heads, protruding from the circular tube-openings, are surrounded with finely branched plumes banded with purple, rose, brown, gray and blue. At intervals, along the branches, gleam the lenses of tiny eyes, having light-sensitiveness

*Dr. Miner served as President of the Academy during the years, 1940 and 1941.

sufficiently keen, so that a shadow passing above them causes the worm to contract quickly into its tube.

Here and there, protrude the mosaic-like margins of the tubes of the sand worm (*Sabellaria communis*), built of carefully selected and matched sand-grains, from which extend the heads of the worms themselves, crowned with circlets of close-set golden spines which move independently, like piano-keys, as they palm food-fragments successively until they drop into the gaping mouth below, with its sensitive tongue sorting over the morsels as they fall.

Blanketing the tube-clusters of these marine worms, and indeed almost the entire surface of the scallop-shell, are irregular brick-red encrustations, which, upon focussing the lens upon them, suddenly display themselves as huge cities of still smaller organisms, dwelling in thousands of closely crowded vase-shaped shells, from the circular openings of which protrude minute golden-yellow lily-like heads, each with a central mouth and translucent stalk-like body. These are a species of moss-animal (*Schizoporella unicornis*). Standing between their close-set shells are erect cylindrical organisms ornamented by series of projecting arms, each terminated by a spherical battery of sting-cells.

From the sides of these delicate creatures, bud saucer-shaped projections, which finally develop radiating tantacles, separate from the parent, and swim away as minute hydroid jellyfish. These are colonies of the hydroid, *Zanclea agassizii*. The story is not ended here, for, by looking closely, one may see, scattered between the hydroids, scores of small, brown, bottle-shaped structures, belonging to the still more minute swallow-tail protozoan (*Folliculina hirundo*), the one-celled translucent inhabitant extending a forked, Y-shaped summit out of the bottle top, equipped with tracts of vibrating cilia, which capture and carry food-particles to the tiny round mouth-opening at the base of the fork.

Now, leaving the scallop-shell with its multitudinous population and picking up a pebble and the bit of rock-weed, we find these, too, are covered with other species of bryozoa. The eel-grass, as well, harbors colony after colony of the ascidian, *Botryllus*

gouldii. These clothe it with a jelly-like substance, in which radiating communities form star-like patterns. Each ray is a separate individual having a terminal incurrent opening, through which water is drawn in with its contained microscopic food, to be passed through the body and cast out from its excurrent opening, grouped with the others at the colony's center. As it emerges, it bears with it swarms of the ascidian's tadpole-like larvae. These swim about actively for a while, by means of a tail stiffened by a notochord. They also possess a brain, dorsal nerve-cord, gill-slits, ventral blood-vessel and an eye-spot, indicating a relationship to the base of the chordate stem. Soon, they settle down to an inactive life, become attached by anterior cement glands to the sub-stratum, acquire a swelled head, lose their nerve and their "back-bone," thus undergoing a metamorphosis, during which their gastronomic and sexual features become highly developed and, thus, they decidedly fall backward in the scale of life, providing an analogy not altogether uncharacteristic of certain members of the human species!

Thus, the apparently dead and insignificant crusts on marine shells and seaweed teem with abundant life in complicated and interwoven associations.

Likewise, let us now visit an inland fresh-water lily-pond, lying quiet among the hills of Maine. From its margin, we gather a few of the delicate submerged water-plants and partially fill a jar with some of the pond-water in which they were growing. We bring it back to the laboratory, and, after allowing it to stand in the window for a few hours, take a little of the water, together with a few strands of the water-plants, and place them in a watch-glass under the microscope. Our first glance shows the water filled with life—protozoa, swimming and darting in all directions. *Stentor*, especially, is particularly abundant, propelling its green oval-shaped body actively, by means of its serried membranelles, or, showing off its protean character by attaching itself at one end, transforming its oval into an elongate, slender-stemmed trumpet; while its membranelles, previously used for propulsion, have now

become a suction apparatus, creating a whirlpool which captures vast quantities of smaller organisms, engulfing them wholesale in its voracious maw. Rotifers are particularly conspicuous. These interesting creatures were the first animals seen through a microscope. When, about the middle of the Seventeenth Century, Leeuwenhoek first turned his newly invented lens on a drop of pond-water, he beheld myriads of minute living creatures, the existence of which had never been suspected. The rotifers at once attracted his attention because of their comparatively large size and abundance. His attention was particularly attracted to a structure crowning their heads, which he mistook for a wheel, rotating about a central axis. Hence, he called them rotifers (wheel-bearers).

Later, with improved lenses, he found that the "wheel" was a circlet of cilia, which, beating the water in rapid succession, gave the visual illusion of rotation.

These creatures occur in fresh water in great abundance and variety, while a smaller number of species are marine. Their habits also are equally diverse. The circlet of cilia (corona), crowning the head region, surrounds the mouth and, by its successive waves of vibration, like a propeller, draws the rotifer forward. The mouth, situated at the base of the funnel, receives the smaller organisms, swept in by the vortex thus created. At times, a rotifer will anchor itself by the pair of toes at the posterior end of the body, when the power of the whirl-pool becomes intensified, the intake of food being increased correspondingly. *Cyrtonia tuba* is such a rotifer, having a circular corona, while *Rotaria macrura* has two circlets side by side. When this species becomes stationary, it will often draw in its corona, enclosing it in a tube-like fold, and will then crawl up the stem of a water-plant, by attaching its head, and drawing up its posterior end like a "measuring worm." *Notommata copeus*, when swimming, expands its corona to form three projections, one on either side, resembling ear-lappets, and one projecting downward in a median position, something like an elephant's trunk. Its feeding habits are

peculiar. It settles down on a filamentary strand of the common pond-scum (*Spirogyra*), draws in its "ear-lappets," extends its throat-jaws, (an apparatus characteristic of rotifers, with many modifications of diagnostic value), bores a neat hole in one of the cylindrical *Spirogyra* cells, and proceeds to pump out the endochrome coiled spirally therein. Then, it crawls up the filament to the next cell and repeats the process, continuing until the entire filament is empty. On the other hand, *Dicranophorus forcipatus* is carnivorous, springing upon its prey, and extending its forcipate jaws to capture it and tear it to pieces.

Water-plants, often associated with rotifers, include not only *Spirogyra*, but also the water thyme (*Anacharis*), and the bladderwort (*Utricularia*). The latter, especially, plays an important part in fresh-water microscopic life and is, at times, crucial for rotifers and other minute creatures of the pond. It is a submerged plant with zigzag stem, having leaves modified to form flattened disk-shaped bladders with an ingenious trap-door at the outer corner, surrounded by spreading branching spines. The stem of *Utricularia* is covered with growths of unicellular algae, diatoms, and desmids, forming a perfect pasture-ground, on which rotifers love to feed. While so engaged, they often become entangled among the spines, and, sooner or later, come in contact with the trap-door of the bladder. A crevice quickly opens with the slightest pressure, and they slip through and are trapped. Soon, they die, suffocated, and gradually macerate. There is no digestive ferment, but the fluid products of decay are absorbed by the plant cells, which is, therefore, carnivorous.

Many rotifer species, such as *Floscularia ringens*, are sessile, forming tubes of mucus or other materials. The species mentioned spins spherical bricks, which it neatly builds into a trumpet-shaped tube. Other rotifers, like *Octotrocha speciosa*, are colonial, forming a spherical jelly-like house, in which the individuals live, radiating out from the center, where they are attached by their tapering toes, and extend their pansy-like heads at intervals from the surface. The members of the *Octotrocha* colony are giants among rotifers, each individual approximating a millimeter in

length. These are but a few of the myriad forms that make up the microscopic associations occuring in fresh water ponds.[1]

The complex worlds of life, contained within such minute areas as encrustations on chance shells and sea weeds, and in a few drops of pond water, could easily be blotted out of existence between thumb and fore-finger. Yet they contain myriads of individuals of infinite variety in crowded array, organized to form interlocking environmental associations. They are born, grow, feed, reproduce and die, meanwhile preying upon each other or avoiding their enemies. All higher animals, including ourselves, without regard to size or so-called position in the scale of evolution, can do no more. Their living substance, protoplasm, is identical with our own. Size is merely an accident. Vital significance does not depend upon it as important, even in the general struggle for existence. A microscopic protozoon, *Trypanosoma gambiense*, swimming in the plasma of our blood, infects us with the dread disease, sleeping sickness. Even ordinary street dust is charged with millions of bacteria, both benign and virulent, and these are drawn into our lungs with every breath. It has been calculated that, a pin's weight of street dust, about one decigram, contains, on the average, 4,000,000 bacteria.

We rate highly the physical courage of the big game hunter who faces a charging bull-elephant in the African jungle. Yet, all the elephants that ever existed have not created as much havoc in the human race as one epidemic of malaria in India. We view with amazement the achievements of mankind in building towering sky-scrapers like the Empire State Building. But if we fly in an air-plane high above the city, the huge structures dwindle into insignificance. A Niagara impresses us with its grandeur; the high peaks of the Rockies inspire us with awe; while the Grand Canyon of the Colorado overwhelms us with the magnificence of its excavation, a mile in depth, and five miles from side to side. Its thousands of sedimentary strata, laid down through the ages,

[1]The speaker, in cooperation with Mr. Frank J. Myers, a noted authority on rotifers, made a survey of a cubic half-inch of pond-bottom, and directed the construction of a group in the American Museum of Natural History, representing this area enlarged 100 diameters, or cubically, 1,000,000 times.

were carved out by water erosion during additional eons of time. Yet, if we could, by some magic, ascend so far above the earth's surface that the whole of the North American continent would lie at once within our vision, Niagara would disappear like the merest trickle; the Rockies become trifling excrescences; and the Grand Canyon, an irregular crackle on the continent.

Before lenses were discovered, mankind lived in a thin, comparatively two-dimensional world, looking sidewise about him at creatures and objects within the limits of his short and imperfect vision. But, with the invention of the telescope and microscope, glass windows were given to man, through which he now gazes into the infinity of the microcosm, on the one hand; and with ultramicroscopic powers, even apprehends rotating systems of the protons and electrons of atomic universes. On the other hand, applying his otherwise weak vision to the telescope, he becomes gifted with visual powers that enable him to penetrate through the starry depths of space, light-year after light-year, universe after universe, into the boundless infinity of the macrocosm. Yet, who can say that these huge distances are not, relatively, of the same proportions as those separating the electronic systems in the ultramicroscopic atom? Size is only relative and the merest accident. Importance lies in energy and, especially, in that organized as protoplasmic life, whether it functions in the single cell of the protozoon or in the complicated centers and tracts of the human brain.

THE NEW YORK ACADEMY OF SCIENCES

Address given at the Annual Dinner and Meeting

December 10, 1941

MR. C. O'D. ISELIN, Director, Woods Hole Oceanographic Institute: *Interaction Between the Hydrosphere and the Atmosphere.** (This address was illustrated by lantern slides).

The interaction between the sea and the atmosphere is no longer a subject which can be dealt with briefly. It will be the subject for discussion at the first meeting of the new Section of Oceanography and Meteorology in March. No doubt, it will also be the chief topic at many subsequent meetings, for of recent years our understanding of the heat exchange and of the momentum transfer between the hydrosphere and the atmosphere has been greatly increased. Thus, to cover any of the basic ideas at all thoroughly, tonight, I must pick and choose, and naturally I will try to emphasize the more recent developments.

At the sea surface, oceanography and meteorology meet. From one standpoint, the force which the winds exert on the ocean surface causes the great ocean currents. From the other point of view, this force is retarding the free flow of the winds. While the winds provide most of the energy, it is the ocean, through its great heat capacity, which modifies the climate and transports some of the heat from low to high latitudes. Furthermore, in the vertical sense, the boundary between the two fields of science is not at all sharp. Meteorologists are concerned with a relatively thick layer of the ocean, while oceanographers must take into consideration the physics of a still deeper air column above the sea surface.

From the standpoint of techniques and instrumentation, the two fields of science are also closely allied. Physical oceanographers and meteorologists should have the same sort of mathematical training. In a number of cases, the same investigator is carrying out work in both fields at the same time. In fact, one

*Contribution No. 312, from the Woods Hole Oceanographic Institution.

might almost say that the main distinction, nowadays, between physical oceanographers and meteorologists, is that the latter group is more inclined to sea sickness.

The classical theory of wind-produced currents in the ocean was developed by Ekman (1928) more than 20 years ago. He showed by very direct and satisfactory mathematical analysis that, in a somewhat idealized ocean in the northern hemisphere, a steady wind should, in a few hours, cause the surface layer to move considerably to the right of the wind direction. At the sea surface, this movement would be 45° to the right of the wind and, at increasing depths, the speed would decrease, but the direction of motion would swing more and more to the right until, at a depth of roughly 100 meters, a weak flow should actually move in a direction opposite to that of the wind. This is the so-called Ekman spiral, the net transport of which is in a direction 90° to the right of the wind in the northern hemisphere, to the left of the wind in the southern hemisphere.

These results, which are due to the earth's rotation, also depend on certain assumptions regarding viscosity and on the existence, near the surface, of a sufficiently deep layer free from vertical temperature gradients. In non-mathematical language, the flow consists of many thin layers of water, each one being dragged along by friction with the layer just above, and being retarded by friction with the layer just below. No systematic vertical motions are involved, and, for the present purposes, this is the most important point to note.

The net transport of the surface layer, which in this way is directly influenced by the wind, will lead to a piling up of the waters on the right hand side of a steady wind and this will set up a gradient current at mid-depths, flowing in the same direction as the wind. Near the bottom, friction will again produce a spiral, but this time to the left of the wind direction. The gradient current at mid-depths will also reduce the angle which the surface water takes. So that once a steady state has been reached, the flow at the surface will be 20°-30° to the right of the wind direction, depending on the strength of the gradient current. This, in

brief, is the theory of ocean currents arrived at by Ekman. His analysis also applies to air currents and the meteorological aspects of his work are much better known than the oceanographic results. Ekman's mathematics is so convincing and his conclusions so logical that, for many years, oceanographers have not been much worried by the fact that nobody was able to show in a convincing manner that the surface wind current consistently diverged markedly to the right of the wind direction.

A few years ago, further elaboration on Ekman's theory by Rossby and others showed, on good theoretical grounds, that the coefficient of friction between the air and the water was, perhaps, not strictly proportional to the wind velocity, but that there should exist one or more critical wind velocities, at each of which the wind-produced current would considerably increase in strength. Provided one of these critical points came within the normal range of variation in the strength of the trade winds, these studies supplied a mechanism whereby ocean currents might fluctuate quite widely in strength over long periods, while the general wind circulation remained relatively steady.

Such, very briefly, is one modern theory of wind-produced currents. Furthermore, during the last year or two, some most interesting observations have been made and these may require a considerable overhauling of Ekman's results.

In the first place, Langmuir (1938), observing the effect of wind on the surface of Lake George, reported alternating bands of convergence and divergence extending down wind, so that the surface motion was broken up into cells. He also called attention to the lines of gulf weed which are frequently seen in the North Atlantic and which never before had been satisfactorily explained. When lines of gulf weed form, they are always parallel to the wind direction.

About the same time, a study of herring gull flight by Woodcock (1940) pointed to a similar pattern of motion in the lower layer of the atmosphere, whenever the air temperatures were lower than the water temperatures. The cells in the air, the streaks of convergence of which are used by the gulls for soaring, are clearly

caused by convection, that is heating from below. Moreover, at low wind velocities, Woodcock showed that only chimney-like updrafts are present, while with winds of from 16 to 28 mph. alternating bands of convergence and divergence obtain. In winds stronger than 28 mph., the gulls are not able to soar at all, no matter how much colder the air is than the water.

Woodcock (1941) then turned his attention to the cells in the water which so nicely account for the streaks of gulf weed. He found that, under most conditions, evaporation from the sea surface is producing a very thin layer of surface water which is colder and therefore heavier than the water just beneath. This cool layer can be seen to drain downward in the lines of convergence. Thus, the motion in the water seems to be also caused by convection, but this point is not yet quite clear, for cells have been observed under conditions where evaporation could not be taking place. Often very small cells can be seen at the surface and these converge into larger cells. When surface cooling is active, the maximum size of the cells is only limited by the thickness of the almost isothermal surface layer.

All of this provides an explanation for many simple phenomena. It explains, for example, why the herring gulls are only observed far off shore during the autumn months. Being lazy creatures and disliking to have to flap their wings more than is absolutely necessary, they keep close to the shore except when the convectional updrafts are well developed. It is now clear why a dry, cool wind kicks up more of a sea than a damp, warm wind of equal strength. A dry, cool wind causes instability and vertical motion in the surface layer and thus the energy of the wind is transferred downward, so that, in effect, the friction between the wind and the water is increased. On the other hand, damp, warm winds slip easily over the sea surface and laminar-like flow occurs in both media. For the same reasons, it is now clear why, in a fog, capillary waves usually do not occur. In a fog, condensation, the opposite from evaporation, is taking place and the surface film of water has very great stability.

The more general oceanographic significance of these ideas

has only very recently been considered. In the first place, wherever the winds are off the land they are relatively dry and, in winter, also much colder than the water. In these areas, a relatively deep convectional layer will be formed and the ocean will gain from the winds much more kinetic energy than in regions where the air is nearly saturated with water vapor. Wherever evaporation occurs, and it occurs over a surprisingly large part of the ocean, vertical movements will be present in the surface layer which will cause a modification of Ekman's spiral. In such areas, the flow will be down wind and not markedly at an angle to the right. It is perhaps for this reason that it has not been easy to demonstrate the sort of flow demanded by Ekman's analysis. Finally, I might point out that if the new ideas are substantiated, the strength of the major ocean currents is not only dependent on the strength of the winds, but also on their humidity and temperature, as well.

One reason why oceanographers have been rather slow in gaining a clear picture of what is going on in the surface layer, is the difficulty of making temperature observations at short distances below the surface. In the first place, the ship is usually rolling, so that a thermometer can not be held at a precise distance below the surface. Second, if the ship is stopped, she is usually drifting sideways and thus destroying the very thermal structure which one might hope to observe in the undisturbed surface waters. These difficulties have recently been overcome by the development of an instrument called the bathythermograph. It consists of an extremely responsive thermal element and a pressure element. When allowed to fall freely through the water, it gives a record of temperature against pressure, that is, depth. It can be worked from ships moving at 10 knots or more and at depths down to 150 meters. Since it can be lowered into the water at 10 feet or more from the ship's side, it records the vertical temperature gradients in undisturbed water and, since each lowering only requires 3 or 4 minutes, the observations can be spaced much more closely in the horizontal direction than is practical with conventional, deep sea, mercurial thermometers. The bathythermo-

graph is giving oceanographers an entirely new conception of the thermal structure in the surface layer. The analogous instrument in meteorology is the balloon sonde, although oceanography will always suffer from the great practical difficulties in obtaining synchronous data from a network of stations.

The bathythermograph not only has confirmed the existence of a nearly isothermal convectional layer at the surface and has shown how the thickness of this layer varies from season to season and from place to place, but it has also shown in satisfactory detail the contacts between contrasting water masses.

On the conventional oceanographic diagram, quite wide interpolations between the observations, both vertically and horizontally, are necessary. For example, the cross current distribution of temperature for such a current as the Gulf Stream is usually worked out from stations spaced 15 to 20 miles apart, at each of which temperature is observed at 100 meter depth intervals, except near the surface, where a 50 meter and a 25 meter reading are also usually obtained.

When the bathythermograph is used with lowerings made at 2 to 3 mile intervals, very much more detail is often disclosed. Near the edges of a current, small horizontal eddies (Spilhaus 1940) with a diameter of 5 or 6 miles are often found. These cause vertical displacements of the isotherms, so that the thermal structure in the surface layer in such regions is a great deal more complicated than could ever be known from thermometer observations.

Near the edge of the continental shelf, the relatively fresh coastal water usually overlies the warmer and more saline off shore water. Because of the relatively wide spacing of thermometer observations in the past, such contacts between contrasting water masses have usually been shown as being quite smooth. But the bathythermograph records call for a complicated interleaving of the water layers both vertically and horizontally.

The slowness whereby turbulence is able to blend water masses having contrasting temperatures and salinities, has, of course, been long recognized. It can be seen off the mouth of any

river. Moreover, at the surface, the edge of such a current as the Gulf Stream is relatively sharp and this has supported the idea that this current resembles a river of warm water flowing through colder seas. However, we have already seen that the Gulf Stream, in reality, occupies the transition zone between cold and warm water masses, so that, at any given depth, except near the surface, its temperature is intermediate. Only at the surface, is the water near the axis of the current slightly warmer than in the Sargasso Sea. Nevertheless, this thin surface film of northward flowing, warm water is a tremendous transporter of heat. This heat is given off to the atmosphere mainly in the area just south and east of the Grand Banks. Recent studies by Jacobs (1941) are showing that, in this area and in the corresponding region of the North Pacific, the air is absorbing great quantities of heat from the sea surface and that this heat transfer has an important effect on the wind system.

The heat exchange due to conduction is, of course, relatively small, but that due to evaporation is surprisingly great. As the relatively dry westerly winds leave the continents, they take up quantities of water vapor, evaporating from the sea surface as much as one centimeter per day in winter. Since, at this season, the air is much colder than the sea, the water vapor is carried aloft rapidly by convection, clouds form, and energy is released through condensation.

Meteorologists have realized, for some time, that the general wind system could not be accounted for on the basis of a single heat source at the equator and cold sources at the two poles. Thus, they have been searching for secondary heat and cold sources.

Through recent studies on the borderline between meteorology and oceanography, it now seems clear that a most important heat source is to be found in mid-latitudes, where the warm waters, carried by the currents away from the equator, meet the relatively cool and dry westerly winds flowing off the continents. Such, in all probability, is a most important cause of the storms which form in the North Pacific and which later give us our weather. In the same way, the Gulf Stream area off this coast

and to the northeastward is a breeding place for storms which move on eastward towards Europe.

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MAURICE L. HUGGINS, Eastman Kodak Company, Rochester, N. Y.: *Thermodynamic Properties of Solutions of Long-Chain Compounds.* (A. Cressy Morrison Prize Winner, 1941.)

The great and rapidly increasing industrial importance of systems containing long-chain compounds needs no emphasis. In spite of their importance, however, most of the progress that has been made in correlating the properties of these systems with their compositions has been made empirically. Much evidence has accumulated to show that many of the theoretical relationships applicable to systems containing only small molecules cannot be applied, without substantial modification, to systems containing giant chain molecules. This has been especially true with regard to solutions. There has been no quantitative theory of the thermodynamic properties of these solutions—those properties (vapor pressures, osmotic pressures, freezing points, boiling points, solubilities, formation of gels and absorption of solvents by them, etc.) which depend directly on the activities of the component substances.

In the present paper, this lack is remedied. Using well-known statistical methods, equations for the activities are derived and shown to be in good agreement with the considerable amount of experimental data in the literature which is suitable for testing them. One can now proceed with confidence, therefore, to apply these equations to other systems than those tested and to all properties (such as those mentioned above) depending on the activities.

The equations derived are also applicable to solutions containing only molecules of small molecular weight. They furnish a means of calculating the magnitude of the effect of the volume, shape and flexibility of the component molecules on the entropy or randomness contribution to the activities—effects usually neglected (for want of a satisfactory theory) but often far from negligible.

OTTO H. HAAS, The American Museum of Natural History, New York, N. Y.: *The Vernay Collection of Cretaceous (Albion) Ammonites from Angola.* (A. Cressy Morrison Prize Winner, 1941)

The Vernay collection of Albian ammonites from Hanha, near Lobito, Angola, contains more than 1,000 specimens, of which almost 700 are sculptured, normally coiled types. They form the basis of this report. The remainder of the collection, consisting of more or less smooth, normally coiled and of abnormally coiled types, will be discussed in later reports. Seven genera, represented by 91 different forms, 61 of which are new, are recognized among the forms treated here.

Although the Lobito fauna has, since 1888, been studied by several different authors, no one has previously had so extensive a collection upon which to base his conclusions. As a result, the present study has rendered possible the elucidation of new facts of importance in the interpretation and understanding of almost every species recognized. Furthermore, the material is such as to allow the description of the species and varieties not only from a purely morphologic point of view, but also from the point of view of the ontogenetic development of the individuals in each species. This latter information has permitted the recognition of phylogenetic trends which are summarized in the concluding chapter of this report.

The richness of this collection is strikingly illustrated by the fact that though not a single specimen referable to the genus *Dipoloceras* has previously been reported from this area, there are 69 specimens, representing 5 different forms, of which 2 are new, here referred to this genus. Likewise, there are more than 300 individuals referable to the genus *Hysteroceras* as contrasted with one specimen figured and a few others mentioned in the previous reports. Twenty-two different forms, 16 of them being new, are recognized among these 303 individuals. It is noteworthy that the majority of these forms appear to be dwarfed, or otherwise slightly varied, local races of species occurring in the European Gault (Albian) deposits.

The previously little known genus *Neokentroceras* is represented by 117 specimens referred to 14 species and varieties, 9 of which are newly described. The greatest number of forms, 24, of which 19 are new, is recognized in the genus *Pervinquieria*. With the exception of *P.arietiformis*, each of these forms is, however, represented by only a few specimens. The representatives of the former species include several complete individuals which attain diameters up to 31 cm. Particularly interesting, also, are some species of this genus, in which the external tubercles of the ornamentation are so strongly developed as to be well described as "horns."

Probably the most characteristic genus of this fauna is *Elobiceras*, represented by 127 specimens included in 18 forms, 11 of which are new. Of particular importance is the occurrence of the true *E.elobiense*, the genotype, which has previously been known only from a single specimen, inadequately described and figured by Szajnocha in 1885.

The other two genera in the fauna, *Prohysteroceras* and *Neoharpoceras*, are not as abundant as the others, the former being represented by 19, the latter by 4 individuals; 6 forms, 2 of them new, are distinguished within *Prohysteroceras* and two, both new, in *Neoharpoceras*.

Another contribution, made possible by the richness of this collection, is the description and illustration of the suture lines of the majority of the species recognized. Most of these, particularly those of *Elobiceras* and of the closely related *Pervinquieria arietiformis*, have been hitherto unknown, or but very incompletely known.

The concluding chapter of the report comprises a "Palaeontological Résumé" of the evidence elucidated by the study of this part of the fauna. First, the problem of possible zonal differentiation within the Albian of Angola is discussed. Observations made in the laboratory prove that *Neokentroceras* and the group of "unkeeled" *Hysteroceras* do not occur together. According to Spath (1934), the former occur at a lower horizon than the latter. Should this zonal sequence be confirmed, the intricate intergeneric

resemblances, here shown in a diagrammatic chart, would permit the assumption of certain phylogenetic relationships between the genera studied so far. These would involve some radical revisions of hitherto prevailing concepts, particularly with regard to the position of the genus *Neokentroceras*. A polyphyletic derivation is indicated for almost all of the genera, and for some groups within them. No evidence suggesting caenogenesis (=proterogenesis Schindewolf) has been found.

ENRIQUE E. ECKER and L. PILLEMER, Institute of Pathology, Western Reserve University, Cleveland, Ohio: *Studies on Complement.* (Awarded Honorable Mention, A. Cressy Morrison Prize Competition, 1941)[1]

Complementary activity has been studied for more than forty years but complement has defied all attempts at isolation. Its properties are only partially known and its structure has not been determined. Indeed, Brocq-Rousseu and Roussel recently stated that "complementary power comprises all the activities of unheated serum."

Complement is usually defined as the non-specific portion of fresh serum, which is not increased by immunization, and which, when added to sensitized cells, results in their destruction. In other words, *complement is still defined in terms of its function and not in terms of its constitution.*

The power of complement to hemolyze sensitized red blood corpuscles is only one of its many properties. Among others are: 1. the lysis of certain sensitized bacteria; 2. the opsonization of certain bacteria; 3. the activation of thermostable immune opsonins; 4. the acceleration or augmentation of the aggregation of certain antigens by their homologous antisera, whether the antigen is a bacterial suspension, a protein in solution, or a suspension of erythrocytes; and 5. the capacity to kill bacteria (bacterial action) in the absence of bacteriolysis.

It has been claimed that there is evidence showing that 6. a thermostable constituent of complement operates in the destruc-

[1]This paper, presented at the Conference on "Immunochemistry," will be published shortly, with others on that subject, in the Annals.

tion of viruses by immune sera. It has been postulated that 7. a toxin-antitoxin complex binds complement *in vivo*, and that, by this mechanism, the toxin is neutralized. Furthermore, 8. complement has been said to be associated with the coagulation processes of blood. However, recent evidence appears to invalidate this last contention. 9. There seems to be a relationship between the sedimentation rate of erythrocytes and complementary activity, i.e., a fast sedimentation rate was found to be related to a low complementary activity. 10. Complement has even been claimed to be associated with muscle contraction.

It should be pointed out that complement, because of its multiple components, may be found to promote one of the aforementioned functions while failing to promote others; e.g., a deficiency of one or more of the components of complement may prevent hemolysis without affecting phagocytosis. Therefore, any activity of complement is determined by the substrate upon which it operates; and it thus becomes necessary in defining complementary activity or titer, to define also the substrate employed. In this paper, unless otherwise noted, the substrate referred to is sheep red corpuscles sensitized with rabbit anti-sheep red cell serum.

Nothing definite is known concerning the active principle or principles in serum responsible for complementary activity or the mode of its action. At various times, it has been suggested that complement is a simple chemical agent like oleic acid, a lypolytic enzyme, a proteolytic enzyme, a catalyst, a peptidase, or, more commonly, a physico-chemical state or a colloidal attribute of fresh serum.

These theories, however, do not explain the fact that complement can be separated into two or more functionally distinct components, each of which is essential for the exhibition of its activity.

G. MARSHALL KAY, Columbia University, New York, N. Y.: *Development of the Northern Allegheny Synclinorium and Adjoining Regions.* (George Frederick Kunz Prize Winner, 1941)

Analysis of the stratigraphy of the Paleozoic sediments in the northern Allegheny synclinorium produces a number of conclusions. Gross deformation was downward through early and middle Paleozoic times. The greatest thickness of sediment is in the terrigenous semilenses (deltageosynclines) that represent depressions accompanying the Taconian and Acadian movements. The Adirondack and Cincinnati axes had arches for limited times, were hinges of oscillation, and were temporally more depressed than the central part of the Allegheny belt, but less than the Michigan autogeosyncline and Champlain miogeosyncline. There can have been synorogenic, eustatic and isostatic movements, but they are not conclusively shown. The southern Allegheny belt is partially concealed beneath the Appalachian allochthone, the marginal thrust of which developed along the Adirondack axis. Appalachian folds extend into the northern synclinorium, paralleling the Appalachian structural front, which has the trend of deltageosynclinal isopachs in the north, and of the margin of the Virginian miogeosyncline in the south.

NEW MEMBERS

Elected December 1 and 19, 1941

SUSTAINING MEMBER

Deats, William, Retired, Private Research, Paleobotany, Barryville, N. Y.

ACTIVE MEMBERS[1]

Aginsky, Burt W., Ph.D., Anthropology, Instructor, New York University, New York, N. Y.

Bateson, Gregory, M.A. (Cambridge), Anthropology.

Beckmann, Charles O., Ph.D., Assistant Professor, Chemistry, Columbia University, New York, N. Y.

Behre, Charles H., Jr., Ph.D., Professor, Geology, Columbia University, New York, N. Y.

Cothran, John C., Ph.D., Chemistry, State Teachers College, Duluth, Minn.

Darling, Hugo, M.D., Ph.D., Private Research, Physics, Takoma Park, Washington, D. C.

David, Pedro A., Ph.D., Assistant Professor, Agronomy, University of the Philippines, Agricultural College, Laguna, P. I.

Dearing, A. Willis, Ph.D., Assistant Professor, Chemistry, Hunter College, New York, N. Y.

Deutsch, Felix, M.D. (Vienna), Research, Clinical Psychosomatic Medicine, Cambridge, Mass.

Duran-Reynals, Francisco, M.D. (Barcelona), Associate Professor, School of Medicine, Yale University, New Haven, Conn.

Eichelberger, William C., Ph.D., Research Chemist, The Solvay Process Company, Syracuse, N. Y.

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Fineman, Agnes D., B.A., Teacher, Biology, Theodore Roosevelt High School, New York, N. Y.

Flood, Walter H., B.S., Consulting Chemical Engineer, Walter H. Flood & Company, Chicago, Ill.

Folkers, Karl A., Ph.D., Chemistry, Assistant Director of Research, Merck & Company, Inc., Rahway, N. J.

Friedenwald, Harry, M.D., Sc.D., D.H.L., Professor Emeritus, Ophthalmology, University of Maryland, Baltimore, Md.

Froning, Henry B., A.M., LL.D., Head, Chemistry and Chemical Engineering; Dean, College of Science, University of Notre Dame, Notre Dame, Ind.

Galbraith, Frederic William, Ph.D., Assistant Professor, Geology, University of Arizona, Tucson, Ariz.

Gaudin, A. M., E.M., Sc.D., Richards Professor, Mineral Dressing, Massachusetts Institute of Technology, Cambridge, Mass.

[1]Shoemaker, Norman Clifford, M.D., Staff Member, Biology and Chemistry, Doctor's Hospital, Washington, D. C., instead of Doctor's Hospital, New York, N. Y., as reported in Transactions, Volume IV, No. 2—Ed.

Gaylor, Peter J., B.S., LL.B., Chemistry, Patent Attorney and Engineer, Union, N. J.

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Howorth, M. Beckett, M.D., Med. Sc.D., Associate, Orthopedic Surgery, Columbia University, College of Physicians and Surgeons, New York, N. Y.

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Kerr, Stanley E., Ph.D., Professor, Biochemistry, American University of Beirut, Syria; Biochemical Research Foundation, Newark, Del.

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ASSOCIATE MEMBERS

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